Solid State Drives for IBM BladeCenter and System x servers

IBM System x at-a-glance guide

IBM® Solid State Drives (SSDs) use nonvolatile flash memory rather than spinning magnetic media to store data. Designed for enterprise blades and servers, the SSDs leverage the extensive history of IBM of meeting enterprise customer expectations in product development, qualification, and ongoing support on a worldwide basis. IBM offers the highest quality enterprise storage devices for enterprise computing environments.

IBM SSDs deliver the performance, power, size, and reliability required for BladeCenter® and System x® application servers. For cost-effective reliability and endurance, and to let customers chose the correct drive to meet business requirements, the IBM SSD family offers both SLC and enterprise-grade MLC technology. With up to 200 GB capacity in a 1.8-inch form factor, this powerful drive provides data loss protection upon power failure. In addition, IBM SSDs support the SATA interface, meaning that there are no compatibility issues. Figure 1 shows a 1.8" solid state drive.

Figure 1. 1.8" solid state drive

Did you know

In terms of I/O operations per second, SSDs can be used in enterprise environments to replace multiple traditional spinning disks, thereby improving application performance, power consumption, reliability, and the total cost of ownership. However, SSDs can also be used as a fast virtual memory paging device to reduce the need for more expensive memory DIMMs, which can lead to reduced server acquisition costs.

SSDs simplify local storage infrastructure to help maintain overall maintenance and cooling cost, while providing remote storage solutions for end-to-end data availability as part of the enterprise ecosystem. SSDs are an appropriate solution for local OS booting, read-intensive applications, and some local storage space. Having originally been developed for the telco and federal marketplace, these SATA-based drives are highly rugged and reliable, and consume very low power. Increasingly, solid state storage is becoming a practical component in balancing datacenter cost, reliability, and manageability.

Part number information

Table 1 lists the information for ordering part numbers and feature codes.

Table 1. Ordering part numbers and feature codes

Description	Part number	Feature code
IBM 50 GB SATA 2.5" SFF Slim-HS High IOPS SSD	43W7714	3745
IBM 50 GB SATA 2.5" SFF HS High IOPS SSD	43W7722	3756
IBM 50 GB SATA 2.5" SFF NHS High IOPS SSD	43W7706	5598
IBM 50 GB SATA 1.8" SSD	43W7734	5314
IBM 50 GB SATA 1.8" MLC SSD	43W7726	5428
IBM 200 GB SATA 1.8" MLC SSD	43W7746	5420

SSD technology

SSDs differ from traditional hard disk drives (HDDs) in many ways, but there is one key difference: no moving parts. Where HDDs contain spinning disks and movable heads that read and write data on the disks, SDDs use solid-state (chip-based) memory to store data. This difference provides SSDs with the following advantages over HDDs:

- High performance input/output operations per second (IOPS): Significantly increases performance I/O subsystems.
- Durability: Less susceptible to physical shock and vibration.
- Longer lifespans: SSDs are not susceptible to mechanical wear.
- Lower power consumption: SSDs use as little as 2.1 watts of power per drive.
- Quieter and cooler running capabilities: Less floor space required, lower energy costs, and a greener enterprise.
- Lower access times and latency rates: About 10 times faster than the spinning disks in an HDD.

SSDs use NAND-based nonvolatile flash memory, the same technology used by USB storage devices, memory cards, mobile phones, and other portable electronic devices that require data storage. However, the type of NAND flash memory that an SSD employs for data storage and retrieval is a key factor for determining the appropriate environment for which the device is employed. Where one methodology might be adequate for the type of usage and environment that the device is intended for (such as a laptop model designed for the consumer market), it might not be feasible for enterprise-class markets where high-performance standards and reliability are key factors for data storage.

Two methods currently exist for facilitating NAND flash memory: single-level cell (SLC) and multi-level cell (MLC). The following sections provide information about each of these technologies.

Single-level cell (SLC) SSDs

SLC flash memory stores data in arrays of floating-gate transistors, or cells, 1 bit of data to each cell. This single bit per cell methodology results in faster transfer speeds, higher reliability, and lower power consumption than that provided by HDDs. SLC SSDs are two-to-three times more expensive to manufacture than MLC devices.

Multi-level cell (MLC) SSDs

The basic difference between SLC flash memory and MLC flash memory technologies is storage density. In comparison with SLC flash memory, which allows only two states to be stored in a cell, thereby storing only one bit of data per cell, MLC flash memory is capable of storing up to four states per cell, yielding two bits of data stored per cell.

Tables 2 and 3 illustrate the differences.

Table 2. SLC single-bit flash memory states

Value	State
0	Full
1	Erased

Table 3. MLC dual-bit flash memory states

Value	State
00	Full
01	Partially programmed
10	Partially erased
11	Erased

MLC flash memory can be further delineated into two categories:

- Consumer-grade MLC (cMLC): Used in consumer (single user) devices such as USB storage devices, memory cards, mobile phones, and so on.
- Enterprise-grade MLC (eMLC): Designed specifically for use in commercial (multiple-user) enterprise environments.

Both cMLC and eMLC flash memory have the advantage of higher data density and the resultant lower cost-per-bit ratio. For practical reasons, this is where the similarities end. The high-density storage model employed by both technologies results in lower write endurance ratios and higher rates of cell degradation than SLC flash memory, greatly reducing the lifetime of the device. For cMLC devices, this does not pose any issues, as the lifetime expectancies are considered adequate for consumer-grade devices. This makes cMLC flash memory ideal for lower-cost, consumer-targeted devices such as memory cards and mobile devices, where cost and market factors outweigh performance and durability.

eMLC provides longer endurance through trimming of components and optimizing certain parameters in the firmware. In addition, eMLC SSDs employ over-provisioning data storage capacity and wear-leveling algorithms that evenly distribute data when the drives are not being heavily utilized. This results in a sixfold increase in write cycles and reduced concerns about cell degradation. While it does not yet match the performance and durability SLC flash memory, it still exceeds lifetime expectancy requirements for enterprise applications.

For industries where enterprise performance and durability is essential, IBM SSDs employ eMLC NAND flash memory to leverage the cost-effective characteristics of MLC flash memory with the performance and reliability of SLC technology.

Table 4 shows the NAND flash memory types used in each currently available SSD option.

Table 4. SSD technology used

Description	Part number	Technology used
IBM 50 GB SATA 2.5" SFF Slim-HS High IOPS SSD	43W7714	SLC
IBM 50 GB SATA 2.5" SFF HS High IOPS SSD	43W7722	SLC
IBM 50 GB SATA 2.5" SFF NHS High IOPS SSD	43W7706	SLC
IBM 50 GB SATA 1.8" SSD	43W7734	SLC
IBM 50 GB SATA 1.8" MLC SSD	43W7726	eMLC
IBM 200 GB SATA 1.8" MLC SSD	43W7746	eMLC

Features and benefits

Table 5 provides a summary of the advantages and disadvantages of SLC and MLC flash. As shown in Table 3, the IBM SSD options are all either SLC or eMLC. As a result, the feature discussions below apply to those technologies and not cMLC.

Table 5. Benefits of SLC and MLC

	SLC	cMLC	eMLC	HDD
High density	N	Y	Y	Y
Low cost per bit	N	Y	Y	Y
Durability	Y	N	Y	N
Low power consumption	Y	Y	Y	N
Read/write speeds (IOPS) (4 K blocks)	4000/1600	20,000/3000	20,000/3000	320/180
Data stability	Y	N	Y	N
Projected life	5 years	1 year	5 years	5 years

High-density storage

As explained in the previous section, the MLC flash memory methods employ multiple bit-per-cell technology, thus resulting in higher data density compared to SLC technology. This means that drives are available in larger capacities.

Cost per bit

At present, HDD storage still has a clear pricing advantage, with a cost per gigabyte ratio as high as 1:10 compared with SDD storage, depending on factors such as drive size, array configuration, and the type of NAND flash memory used (SLC flash cost-per-bit is three times as much as MLC flash). However, this gap has been closing as SDD technology becomes less expensive and more prevalent.

One solution to offset costs is to use SDDs for server drives that only perform the most I/O-intensive operations, such as boot drives, caching, and swap space. This provides lower latency rates and higher throughput for application-critical operations. SDDs can also be employed in RAID arrays for fault tolerance and data sharing.

Durability

Because flash memory does not have the mechanical limitations of traditional spinning hard drives, SSDs are less susceptible to shock and vibration and have a higher tolerance for wide temperature and humidity ranges.

Low power consumption

Replacing HDDs with SSDs results in a lower cost and greener enterprise. Because there are fewer storage devices needed, fewer resources (such as controllers, switches, and racks) are needed, resulting in:

- A smaller footprint in the enterprise
- Quieter operation
- Reduced cooling requirements
- Reduced power requirements
- Reduced floor space

These reductions result in an overall lower total cost of ownership.

Performance

Because there are no moving parts, startup times are small because no spin-up or seek time is required. For example, when an HDD retrieves a large file, it searches for the file in passes with each revolution of the spinning disk, resulting in access times of 10 - 15 ms on average. An SSD can retrieve the same file as quickly as 0.1 ms. This makes SDD server usage ideal for applications where throughput is more important than capacity, such as video distribution and financial analysis.

The improved application performance of SSDs results in increased and more reliable transactions in less time. A comparison of IBM high-performance SSDs with traditional enterprise-level HDDs demonstrates a dramatic increase in overall I/O operations per second (IOPS), as shown in Table 6.

Table 6. IOPS comparison

	HDD (3.5" 15 K)	HDD (2.5" 15 K)	SLC SSD	MLC SSD
Write IOPS	300	250	1600	3000
Read IOPS	390	300	4000	20,000
Cost per IOPS ($)	$0.52 (146 GB)	$0.83 (146 GB)	$0.09 (50 GB)	$0.04 (50 GB)

Note: All results with 4 K block transfers

Stated another way, if your application's demands can be met by implementing a large RAID array of HDDs, you can use far fewer SSDs and achieve the same performance.

Data reliability

SLC and E-MLC solid-state drives utilize several techniques to ensure data stability and retention:

- Wear-leveling algorithms that evenly distribute data across the drive.
- Garbage collection that uses an algorithm to select the blocks in the memory to erase and rewrite.
- For correctable errors, the drives use an ECC scheme (twenty-four 9-bit symbols using Reed Solomon).

- For uncorrectable errors, the drives use the Redundant Array of Independent Silicon Elements (RAISE) scheme, which allows the controller to rebuild data that was located on a failed flash page or block somewhere else on the drive.
- For undetectable errors, there is data path protection (CRC-32 bit).

SATA

Migrating your enterprise storage to SSD is relatively painless because solid state drives support the SATA protocol used by HDDs. Coexistence is also possible because of this. Figure 2 shows the x3690 X5 with 1.8-inch SSDs and 2.5-inch SAS drive bays.

Figure 2. Eight solid state drives installed in an x3690 X5 server (up to 24 supported)

Specifications

Table 7 presents technical specifications for the drives.

Table 7. Specifications

Specification	IBM 50GB SATA 2.5" SFF Slim-HS High IOPS SSD	IBM 50GB SATA 2.5" SFF HS High IOPS SSD	IBM 50GB SATA 2.5" SFF NHS High IOPS SSD	IBM 50GB SATA 1.8" SSD	IBM 50GB SATA 1.8" MLC SSD	IBM 200GB SATA 1.8" MLC SSD
Part number	43W7714	43W7722	43W7706	43W7734	43W7726	43W7746
Interface	SATA I	SATA I	SATA I	SATA I	SATA II	SATA II
Hot-swap drive	Yes	Yes	Yes	Yes	Yes	Yes
Form factor	2.5" SFF	2.5" SFF	2.5" SFF	1.8" SFF	1.8" SFF	1.8" SFF
Capacity	50 GB	50 GB	50 GB	50 GB	50 GB	200 GB
IOPS read*	4000	4000	4000	4000	20,000	20,000
IOPS write*	1600	1600	1600	1600	3000	3000
Sequential read rate	80 MBps	80 MBps	80 MBps	80 MBps	140 MBps	150 MBps
Sequential write rate	50 MBps	50 MBps	50 MBps	50 MBps	18 MBps	35 MBps
Shock, operating	2 ms: 60 Gs	2 ms: 60 Gs	2 ms: 60 Gs	2 ms: 60 Gs	1 ms: 1500 Gs	1 ms: 1500 Gs
Shock, nonoperating	2 ms: 300 Gs	2 ms: 300 Gs	2 ms: 300 Gs	2 ms: 300 Gs	1 ms: 1500 Gs	1 ms: 1500 Gs
Temperature, operating	0 - 70°C	0 - 70°C	0 - 70°C	0 - 70°C	0 - 70°C	0 - 70°C
Temperature, nonoperating	-40 - 70°C	-40 - 70°C	-40 - 70°C	-40 - 70°C	-40 - 90°C	-40 - 90°C
Power operating	2.1 W	2.1 W	2.1 W	2.1 W	1 W	1 W
Power idle	.5 W	.5 W	.5 W	.5 W	0.8 W	0.8 W

* Results with 4 KB block transfers

Warranty

There is a 1-year, customer-replaceable unit (CRU), limited warranty.

Supported disk controllers

The solid-state drives require a supported disk controller. The supported System x controllers are listed in Table 8.

Table 8. Support RAID controllers for System x servers

RAID controller	Part number	Support SSDs
ServeRAID M5025 SAS/SATA Controller	46M0830	No
ServeRAID M5015 SAS/SATA Controller	46M0829	Planned†
ServeRAID M5014 SAS/SATA Controller	46M0916	Planned†
ServeRAID M1015 SAS/SATA Controller	46M0831	No
ServeRAID B5015 SSD Controller	46M0969	Yes
IBM 6 Gb SSD Host Bus Adapter	7838-AC1 fc 3876*	Yes
IBM 6 Gb SAS HBA	46M0907	No
IBM 3 Gb SAS HBA Controller v2	44E8700	No
ServeRAID MR10M SAS/SATA Controller	44E8825	No
ServeRAID MR10i SAS/SATA Controller	43W4296	No
ServeRAID MR10is VAULT SAS/SATA Controller	44E8695	No
ServeRAID MR10k SAS/SATA Controller	43W4280	No
ServeRAID BR10i SAS/SATA Controller	44E8689	No
ServeRAID BR10il SAS/SATA Controller	44X0411	No
ServeRAID BR10il SAS/SATA Controller v2	49Y4731	No

* The IBM 6 Gb SSD Host Bus Adapter is only available for configure-to-order (CTO) configurations. The building block (SBB) part number is 46M0912.
† For use with SSDs, the ServeRAID M5015 and M5014 require the addition of the ServeRAID M5000 Series Performance Accelerator Key, part number 81Y4426.

Supported servers

The solid state drives and supported RAID controllers can be installed in the System x servers identified in Table 9.

Table 9. Supported servers

	IBM 6 Gb SSD HBA	ServeRAID B5015	ServeRAID M5014†	ServeRAID M5015†
Part number	fc 3876*	46M0969	46M0916	46M0829
IBM System x3200 M3	N	N	Y	Y
IBM System x3250 M3	N	N	Y	Y
IBM System x3400 M3	N	N	Y	Y
IBM System x3500 M3	N	N	Y	Y
IBM System x3550 M3	Y	Y	Y	Y
IBM System x3620 M3	N	N	Y	Y
IBM System x3630 M3	N	N	Y	Y
IBM System x3650 M3	Y	Y	Y	Y
IBM System x3690 X5	Y	Y	Y	Y
IBM System x3755 M3	N	N	Y	Y
IBM System x3850 X5	Y	Y	Y	Y

* The IBM 6 Gb SSD Host Bus Adapter is only available for configure-to-order (CTO) configurations. The building block (SBB) part number is 46M0912.
† For use with SSDs, the ServeRAID M5015 and M5014 require the addition of the ServeRAID M5000 Series Performance Accelerator Key, part number 81Y4426.

See the IBM ServerProven® website for the latest information about the adapters supported by each System x server type: http://ibm.com/servers/eserver/serverproven/compat/us/

The solid state drives are also supported in BladeCenter servers, as listed in Table 10.

Table 10. Supported BladeCenter servers

Expansion card	Part number	HS12	HS21	HS21 XM	HS22	HS22V	HX5	JS23/JS43	PS700/1/2	PS703/4
IBM 50 GB SATA 2.5" SFF Slim-HS High IOPS SSD	43W7714	N	N	N	Y	N	N	N	N	N
IBM 50 GB SATA 2.5" SFF HS High IOPS SSD	43W7722	N	N	N	N	N	N	N	N	N
IBM 50 GB SATA 2.5" SFF NHS High IOPS SSD	43W7706	Y	Y	Y	N	N	N	N	N	N
IBM 50 GB SATA 1.8" SSD	43W7734	N	N	N	N	Y	Y	N	N	N
IBM 50 GB SATA 1.8" MLC SSD	43W7726	N	N	N	N	Y	Y	N	N	N
IBM 200 GB SATA 1.8" MLC SSD	43W7746	N	N	N	N	Y*	Y*	N	N	Y

* Support is planned

Supported operating systems

Solid state drives operate transparently to users, storage systems, applications, databases, and operating systems. The controllers that support SSDs are supported by the following operating systems:

- Microsoft Windows Server 2003, Web Edition
- Microsoft Windows Server 2003/2003 R2, Datacenter Edition
- Microsoft Windows Server 2003/2003 R2, Datacenter x64 Edition
- Microsoft Windows Server 2003/2003 R2, Enterprise Edition
- Microsoft Windows Server 2003/2003 R2, Enterprise x64 Edition
- Microsoft Windows Server 2003/2003 R2, Standard Edition
- Microsoft Windows Server 2003/2003 R2, Standard x64 Edition
- Microsoft Windows Server 2008 R2
- Microsoft Windows Server 2008, Datacenter x64 Edition
- Microsoft Windows Server 2008, Datacenter x86 Edition
- Microsoft Windows Server 2008, Enterprise x64 Edition
- Microsoft Windows Server 2008, Enterprise x86 Edition
- Microsoft Windows Server 2008, Standard x64 Edition
- Microsoft Windows Server 2008, Standard x86 Edition
- Microsoft Windows Server 2008, Web x64 Edition
- Microsoft Windows Server 2008, Web x86 Edition
- Microsoft Windows Small Business Server 2003/2003 R2 Premium Edition
- Microsoft Windows Small Business Server 2003/2003 R2 Standard Edition
- Microsoft Windows Small Business Server 2008 Premium Edition
- Microsoft Windows Small Business Server 2008 Standard Edition
- Red Hat Enterprise Linux 4 AS for AMD64/EM64T
- Red Hat Enterprise Linux 5 Server Edition
- Red Hat Enterprise Linux 5 Server Edition with Xen
- Red Hat Enterprise Linux 5 Server with Xen x64 Edition
- Red Hat Enterprise Linux 5 Server x64 Edition
- Red Hat Enterprise Linux 6 Server Edition
- Red Hat Enterprise Linux 6 Server x64 Edition
- SUSE LINUX Enterprise Server 10 for AMD64/EM64T
- SUSE LINUX Enterprise Server 10 for x86
- SUSE LINUX Enterprise Server 10 with Xen for AMD64/EM64T
- SUSE LINUX Enterprise Server 11 for AMD64/EM64T
- SUSE LINUX Enterprise Server 11 for x86
- SUSE LINUX Enterprise Server 11 with Xen for AMD64/EM64T
- Solaris 10 Operating System
- VMware ESX 4.0
- VMware ESX 4.1
- VMware ESXi 4.0
- VMware ESXi 4.1

See the IBM ServerProven website for the latest information about the specific versions and service packs supported: http://ibm.com/servers/eserver/serverproven/compat/us/. Click **System x servers**, then **Disk controllers** to see the support matrix. Click the check mark that is associated with the System x server in question to see the details of the operating system support.

Related publications

For more information see to the following documents:

- IBM Redbooks® at-a-glance guide for ServeRAID M5015 and M5014 SAS/SATA Controllers
  http://www.redbooks.ibm.com/abstracts/tips0738.html?Open
- IBM Redbooks at-a-glance guide for the ServeRAID B5015 SSD Controller
  http://www.redbooks.ibm.com/abstracts/tips0763.html?Open
- *ServeRAID M5015 and M5014 SAS/SATA Controllers User's Guide*
  http://www.ibm.com/support/docview.wss?uid=psg1MIGR-5082936
- System x RAID products home page
  http://ibm.com/systems/x/options/storage/solidstate/
- IBM ServeRAID software matrix
  http://www.ibm.com/support/docview.wss?uid=psg1SERV-RAID
- *IBM System x Configuration and Options Guide*
  http://www.ibm.com/support/docview.wss?uid=psg1SCOD-3ZVQ5W

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